

June 19, 1945.

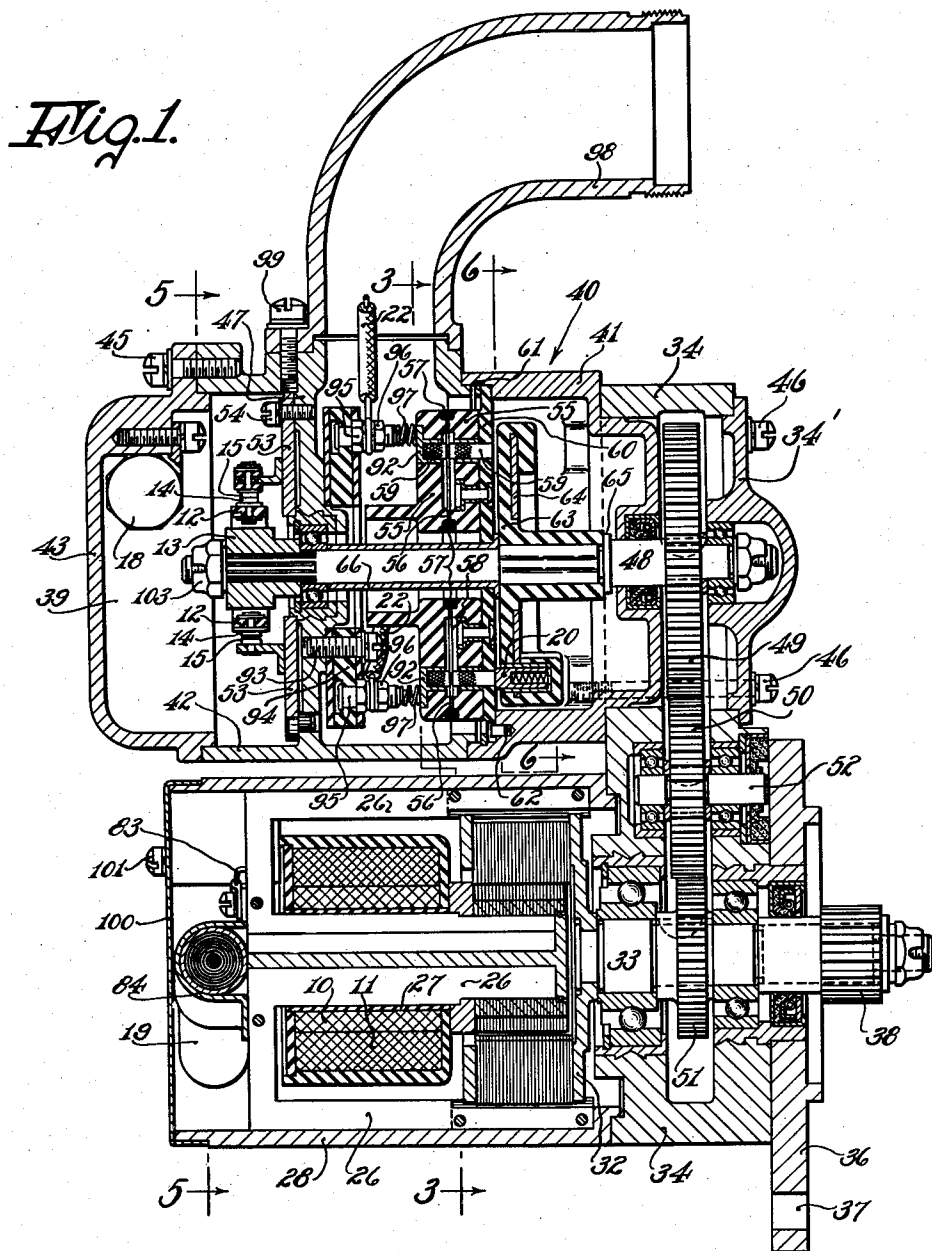
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2,378,705

IGNITION SYSTEM AND MAGNETO THEREFOR

Filed Jan. 22, 1943

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 3.

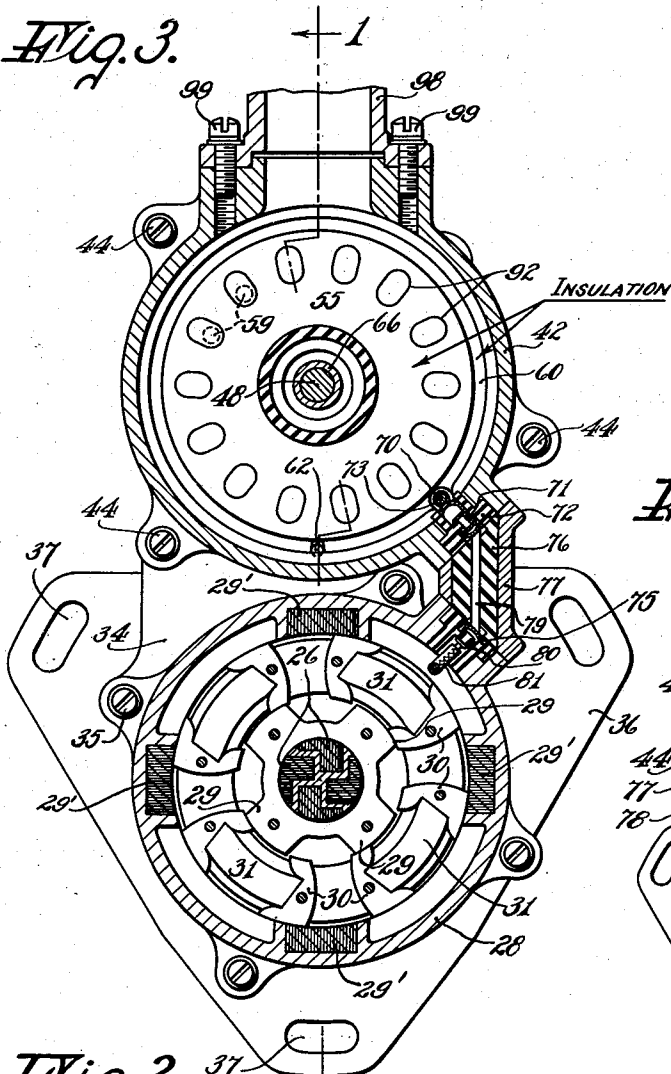


Fig. 4.

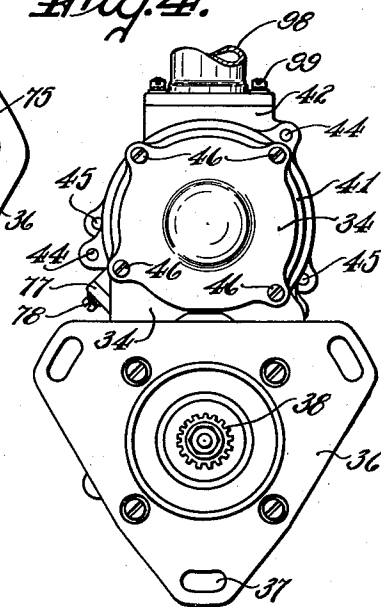
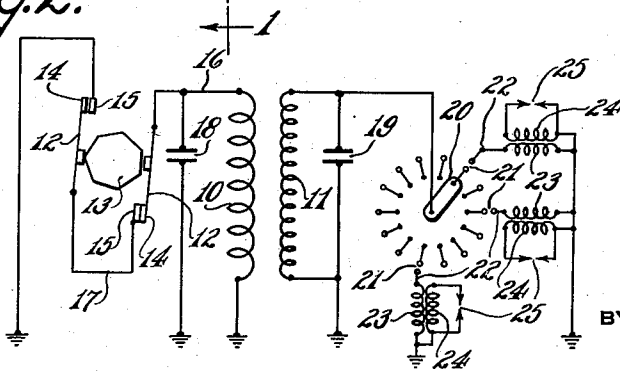


Fig. 2.



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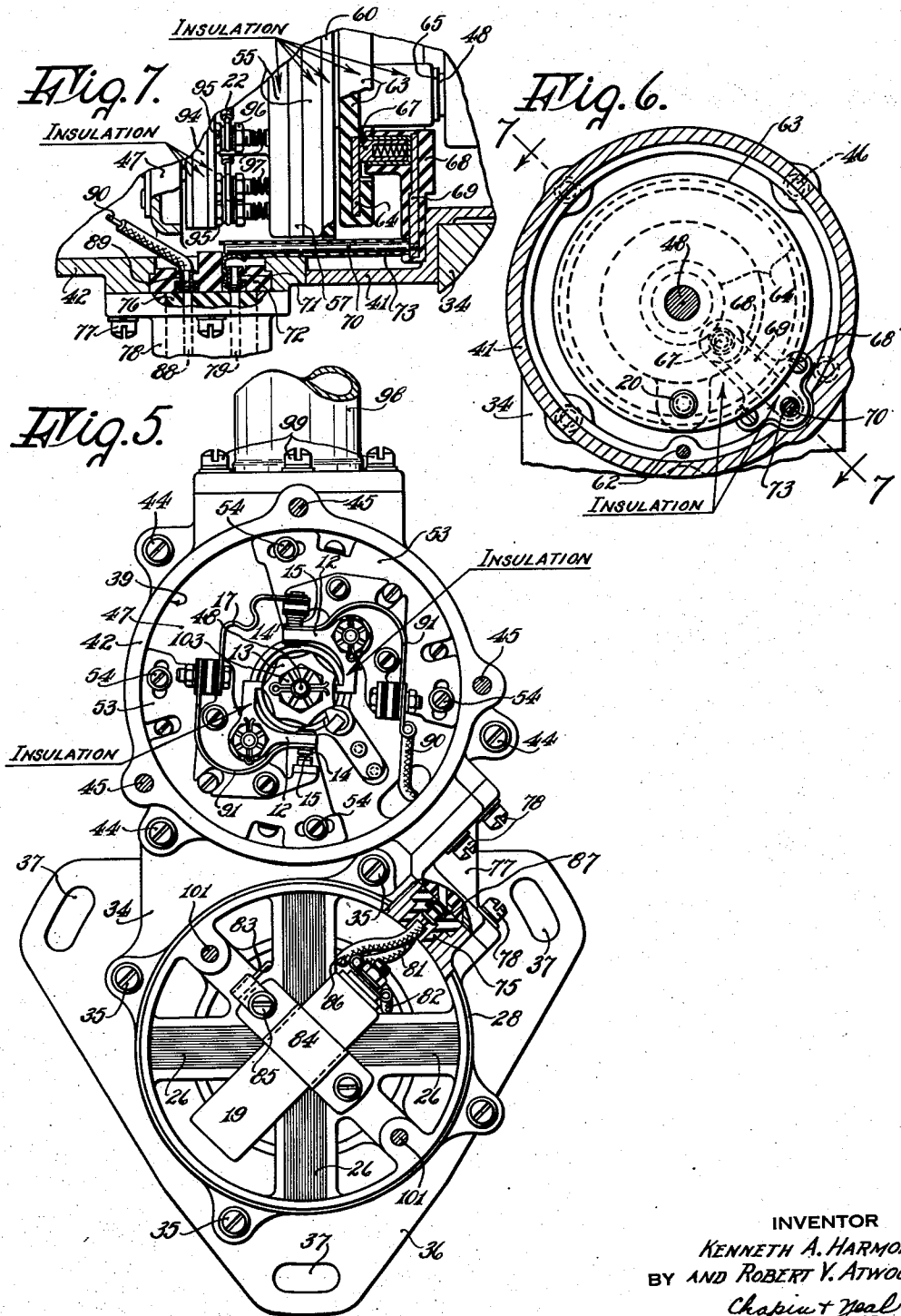
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3 Sheets-Sheet 3



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2,378,705

IGNITION SYSTEM AND MAGNETO
THEREFOR

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Application January 22, 1943, Serial No. 473,182

8 Claims. (Cl. 315—213)

This invention relates to an improved ignition system and to an improved magneto for use in such system.

One object of the invention is to provide an ignition system, having an oscillating circuit of medium high frequency and having distribution of the oscillating discharge at low tension to the spark plug transformers at the engine cylinders.

The frequency of the discharge is low enough so that distribution losses are negligible and so that close tuning of the primary and secondary oscillating circuits is unnecessary. Thus, the length of the distribution wires is not critical and discrepancies between the various spark plugs is a negligible factor. Lead wires of different length may therefore be used, and although this may result in lack of balance between the oscillating circuits there will be no substantial sacrifice in the efficiency of the system. At the same time, the frequency of the discharge is high enough so that very little loss is sustained by leakage in fouled spark plugs. The low tension distribution makes radio shielding capacity losses negligible and obviates the use of special high tension cables.

Another object of the invention is to provide in an ignition system a plurality of spark gaps, one for each cylinder of the engine and located one in each low tension circuit leading from the distributor, characterized in that all said gaps are contained in a single unit which may be easily removed and replaced when servicing is required.

A further object of the invention is to locate the aforesaid spark-gap unit in the magneto so that it may be serviced at the same time the breaker mechanism is serviced.

A further object of the invention is to provide in association with a magneto having primary and secondary coils, engine-driven means for effecting changes of magnetic flux through said coils and breaker mechanism operating in timed relation with the engine for controlling the circuit of the primary coil; a condenser charged by the secondary coil, spark gaps one for each engine cylinder, a distributor driven in timed relation to the engine to successively connect said condenser to the spark gaps, and lead wires leading one from each spark gap to spark plug transformers located one at each engine cylinder; said condenser, distributor and spark gaps being all contained in a group with the above-named magneto elements on a common support.

These and other objects will best be understood

as the detailed description proceeds and they will be pointed out in the appended claims.

The invention will be disclosed with reference to the accompanying drawings, in which:

Fig. 1 is a sectional elevational view, taken on the line 1—1 of Fig. 3, of an improved ignition apparatus for use in the improved ignition system;

Fig. 2 is a diagrammatical view of the improved ignition system;

Fig. 3 is a cross sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is an end view taken from the right hand side of Fig. 1 and drawn to a smaller scale;

Figs. 5 and 6 are cross sectional views taken on the lines 5—5 and 6—6, respectively, of Fig. 1; and

Fig. 7 is a fragmentary sectional elevational view taken on the line 7—7 of Fig. 6.

Referring first to Fig. 2 of the drawings, the complete ignition system is here shown in diagrammatical form. The source of electrical energy is a magneto, including primary and secondary coils 10 and 11, respectively, and breaker mechanism for controlling the primary circuit, opening and closing it in properly timed relation with the engine. The breaker mechanism includes two breaker arms 12 operated alternately by a rotatable, seven-lobed cam 13 which is driven at half engine speed, this particular arrangement being designed for a 14 cylinder, four-cycle internal combustion engine. Each arm 12 carries a breaker point 14 which cooperates with a stationary breaker point 15. The two pairs of breaker points and the primary coil 10 are connected in a series circuit by wires 16 and 17, one terminal of coil 10 and one breaker point 15 being grounded as shown. A condenser 18 is bridged across the breaker points in the usual manner and for the usual purpose. The circuit of the system just described is the same as the usual primary circuit of the magneto.

The secondary coil 11 of the magneto is connected to charge a condenser 19 at properly timed intervals. A rotatable distributor arm 20, driven at half engine speed, operates to successively connect one terminal of condenser 19 to a series of spark gaps 21, one for each cylinder of the engine. Each gap 21 is connected by a low tension distributor wire 22 to one terminal of the primary 23 of a spark plug transformer. The other terminal of primary 23 is grounded as is one terminal of secondary coil 11 and condenser 19. There are thus a plurality of primary oscillating circuits successively connected by the

distributor to receive the discharge from the condenser 19. The secondary coil 11 is not the same as the usual magneto secondary coil and, as distinguished therefrom, has substantially less turns and is of larger wire. It may, for example, have from one-fifth to one-tenth the number of turns of the usual secondary coil of a magneto.

There are as many secondary oscillating circuits in the system as there are cylinders in the engine. Each such circuit includes the secondary 24 of a spark plug transformer and a spark plug 25, one terminal of secondary 24 and one terminal of plug 25 being usually grounded, as indicated. Only three such circuits have been illustrated but it will be understood that there are fourteen in this particular case.

The system operates as follows. On each opening of the primary circuit effected by the breaker mechanism, energy in the secondary coil 11 is released and the condenser 19 is charged. In an extremely short time, the voltage across the condenser builds up to a value high enough to fire the particular spark gap 21 which is then connected in circuit by distributor arm 20. This gap 21 breaks down, allowing the condenser to discharge into that primary 23 which is at that time connected in circuit with said gap. Oscillations take place at a frequency determined by the constants of the primary oscillating circuit and these oscillations are transmitted by mutual induction into the secondary 24, which is associated with said primary. Because of the many turns in secondary 24 compared to primary 23, a high voltage is produced at the electrodes of the spark plug 25, connected thereto. The transformer is large enough to handle sufficient energy to produce the desired hot spark.

The distribution is distinctly low tension. The highest voltage reached in the circuit of condenser 19 is substantially 800 and such voltage prevails only up to the particular spark gap 21 being fired. In the remainder of this circuit, which includes a distribution wire 22 and a primary coil 23, the mean voltage is very low. The distribution voltage is low enough to render radio-shielding capacity losses negligible. The frequency is relatively low as compared to the frequencies commonly employed in oscillating circuits for ignition purposes. The frequency used in the present system is, for example, approximately one hundred kilocycles. This frequency is nevertheless high enough to yield the advantage of very small loss by leakage in fouled spark plugs but it is low enough to render distribution impedance losses negligible. This makes feasible an important feature of the invention viz., the location of the condenser 19, the distributor and all of the spark gaps 21 on the same frame or support with the magneto. Thus, uninterrupted low-tension distribution wires may be used to extend from the magneto to the spark plugs and their transformers, each transformer being located at the engine and preferably combined with the plug as one unit. These distribution wires may be of different lengths. At least the length of these wires is not critical because of the use of relatively low frequency which does not necessitate close tuning of the primary and secondary oscillating circuits. In the really high frequency systems, the secondary and primary must be tuned as closely as possible to secure maximum transfer of energy. The total inductance in the primary oscillating circuit then needs to be constant and distribution wires of varying length are decidedly objectionable. Here, with

the low frequency used, the nicely-tuned circuits are not of the essence. Actual unbalance, due to distribution wires of different length, can exist without any serious loss and the discrepancies between the various spark plugs becomes negligible.

It is important and essential to a commercially satisfactory ignition system for engines having a large number of cylinders, such as airplane engines for example, that there be many spark gaps, such as 21. A single gap, serving for each spark plug, would not be feasible because of the exceedingly short time available in which to dissipate the heat resulting from firing of the gap. The use of one gap for each cylinder enables much more time in which to dissipate the heat and accordingly greatly reduces wear on the electrodes of the gap and greatly prolongs the useful life of the same.

In Figs. 1 and 3 to 7 inclusive, there is shown a magneto for use in the system described and having associated therewith the condenser 19, distributor and all the spark gaps 21.

Referring first to Figs. 1 and 3, there is shown a magneto of the same general type as that disclosed in U. S. Patent No. 2,300,117, except for the change above noted in the secondary coil. The stator consists of four angularly-spaced U-shaped laminated members 26, the inner legs of which all pass through the central opening in the core 27 on which coils 10 and 11 are mounted. The outer legs and cross bar portions and the inner legs of members 26 are embedded in the non-magnetic metal of which the generally cylindrical housing 28 is formed, as indicated. The right hand ends of the inner legs terminate with pole pieces 29 and the corresponding ends of the outer legs terminate with pole pieces 29'. Cooperating with these pole pieces are the pole shoes 30 of a magnetic rotor which is best shown in Fig. 3. Short permanent bar magnets 31 interconnect each pair of pole shoes and the shoes and magnets are suitably fixed to a non-magnetic face plate 32 which in turn is secured to one end of a drive shaft 33 (Fig. 1). Shaft 33 is rotatably mounted in ball bearings in a frame 34 to which casing 28 is suitably secured as by the cap screws 35 shown in Fig. 3. Fixed to frame 34 is a face plate 36 adapted to be secured, as by bolts applied through holes 37, to the crankcase of the engine with the inner end of shaft 33 extending into the crankcase. Said end of shaft 33 bears a gear 38 for connection to suitable engine driven gearing (not shown). The arrangement is such that shaft 33 is driven at seven-eighths engine speed. The magneto is adapted to make and break the magnetic circuits through coils 10 and 11 eight times per revolution of shaft 33. Since only seven such breaks per revolution of the engine crankshaft are required, the shaft 33 is geared to turn at seven eighths crankshaft speed.

The breaker mechanism for the magneto is contained in the outer chamber 39 (Figs. 1 and 5) of a generally cylindrical housing 40 which is also suitably fixed to the above-described frame 34 and in parallel and closely adjacent relation to housing 28. Housing 40 is constructed in three sections, two body sections 41 and 42, and a cap section 43. The sections 41 and 42 are held together by the cap screws 44 shown in Figs. 3 and 5 and the sections 42 and 43 are held together by the cap screws 45 indicated in Fig. 5. The section 41 is held to frame 34 by the cap screws 46 (Fig. 4). These same cap screws also serve to hold in place a cap 34, the screws passing through the cap and frame and threading into the section

41 as indicated in Fig. 1. The section 42 has a partition 47 therein. Rotatably mounted in ball bearings located one in the partition 47 and one in a cap 34' on frame 34, is a shaft 48 on the outer end of which is fixed the seven lobed breaker cam 13. Shaft 48, on its inner end, has fixed thereto a gear 49 which is connected by an intermediate gear 50 to a gear 51 fixed on the rotor shaft 33 of the magneto. Gear 50 is supported on an idler shaft 52, mounted in ball bearings in frame 34. The gearing is such that shaft 48 is driven at one-half engine speed. Accordingly, the breaker cam effects seven breaks in the primary circuit per revolution of the engine and these are timed to occur simultaneously with the seven breaks in the magnetic circuit which are effected during each revolution of the engine. The breaker mechanisms are shown in Fig. 5. Each mechanism is mounted on a plate 53, secured by screws 54 to partition 47. Each breaker arm 12 is of insulating material. The stationary breaker point 15 for the upper breaker mechanism shown in Fig. 5 is insulated and the other stationary breaker point 15 is grounded. The condenser 18 is mounted in chamber 39 as indicated in Fig. 1. Further description of the breaker mechanisms is thought to be unnecessary to an understanding of the present invention. For a more complete disclosure of the breaker mechanisms, reference is made to U. S. Patent No. 2,282,581.

The many spark gaps 21 are all contained within a single unit which is mounted in the housing section 41 for convenient removal. This unit includes two companion members 55 (Fig. 1) of porcelain or the like which are constructed in annular form with inner and outer marginal rims of annular form. These rims abut intervening thin spacer rings 56 of mica. The rims have a special glaze which can be soldered and these two members are fastened together by solder (indicated at 57) and form between them a chamber 58. This chamber is exhausted of air and filled with an inert gas, such as nitrogen. The electrodes 59 of each gap are fixed one in each member 55 with their inner ends extending into the chamber 58. The electrodes are thus hermetically sealed in a non-oxidizing atmosphere. The inner faces of the fourteen electrodes in each member 55 are finished flush with the marginal rims thereof. Then when the companion members are placed together, the inner faces of each pair of electrodes will be separated by a distance equal to the thickness of the spacing rings 56, say .006 inch for example. One member 55 is fixed as by the rivets shown to a disc 60 which is of insulating material and larger in diameter than the member. One set of electrodes extend through this disc, terminating flush with the inner face thereof. This disc 60 abuts a shoulder in the circumferential wall of section 41 and is held thereto by a snap ring 61, which fits into a groove in said wall. A pin 62, fixed in said wall, fits into a notch in disc 60 and prevents the same from turning. This disc forms a track for the distributor brush.

The distributor brush 20 comprises a spring-pressed contact to ride on the inner face of disc 60. This contact is mounted in a circular disc 63 of insulating material in electrical connection with an annular ring 64 of conducting material, such ring being embedded in the member 63. The disc 63 has a central hub which is mounted on shaft 48, abutting a flange 65. The shaft, where it extends through this hub, is flattened as indicated in Fig. 1 and the hub is correspondingly

formed to insure a driving engagement between the two. The disc 63 is held against flange 65 by means of a spacer sleeve 66 on shaft 48 which sleeve extends from the inner race of the outer bearing for such shaft to the outer face of disc 63.

The annular conducting ring 64 is at all times engaged by a spring-pressed brush 67 (Figs. 6 and 7) mounted in an arm 68, secured to section 41 as by screws 68' (Fig. 6), and containing a conductor 69 electrically connected at its inner end to the brush. A metal rod 70 is connected at one end to conductor 69 and at the other end is engaged by one spring finger of a contact 71 fixed in a plug 72 of insulating material mounted in a hole in housing section 42. The remainder of rod 70 is covered with an insulating sleeve 73. Referring to Fig. 3, a similar plug 75 of insulating material is mounted in a hole in casing 28 and the two plugs 72 and 75 are held to their seats in their respective holes by a member 76 of insulating material mounted in a metal part 77 which is secured to the casing members 28 and 42 by screws 78 (Fig. 4). Within member 76 is a conductor 79 which connects a second spring finger of contact 71 to a spring finger on a contact 80 fixed in plug 75. To this contact is connected a wire 81 which is connected to one terminal of condenser 19 (Fig. 5). A wire 82 connects the same terminal of condenser 19 to one terminal of the secondary coil 11. The other terminal of the secondary coil and one terminal of the primary coil are grounded by the wire 83 to the clip 84 and its retaining screw 85 by means of which condenser 19 is held in position in the outer end portion of casing 28. The other terminal of the condenser is connected to its casing which is grounded by clip 84 to the metallic casing 28. By the means described, the condenser 19 is connected to the distributor brush 20.

The primary wire 16 of the diagram in Fig. 2 is actually composed of several parts as set forth below. A wire 86 connected to the ungrounded terminal of primary coil 10 extends to a second contact 87 in plug 75 and is connected by a second conductor 88 in member 76 to a second contact 89 in plug 72. This contact 89 is connected to a wire 90 which extends to the conducting spring 91 of the upper breaker arm 12 in Fig. 5.

Referring again to Fig. 1, the outermost member 55 of the removable and replaceable spark gap unit has embedded in its outer face fourteen contacts 92 equally spaced in a circular series and electrically connected one to each of the electrodes 59 of one set. Fixed to the partition 47, as by cap screws one of which is shown at 93, is a terminal board 94 made up of three discs of insulating material and having fixed therein, equally spaced in a circular series, fourteen studs 95 aligned one with each of the contacts 92. These studs are riveted to the central disc of the terminal board; the heads of the studs are covered by the outer disc of the board; and the inner disc has a circular series of hexagonal holes to receive the hexagonal parts of studs 95 and prevent them from turning. The leads or distribution wires 22 are connected one to each stud 95 by nuts 96. Each stud 95 has fixed to its inner end a spring 97. These springs 97 engage one with each of the contacts 92 and are compressed to some extent when put in place and thereby press tightly against the contacts.

The leads 22 leave the casing 40 through an elbow 98 secured to casing section 42 by cap screws 99. This elbow forms part of a conduit through which the leads 22 pass to the several

spark plug transformers. This conduit may be conveniently separated, leaving the elbow 98 attached to section 42 as shown. The leads also may be conveniently disconnected at the same point in any suitable way, as for example by the familiar pin jack, one part of which is fixed in the outer end of elbow 98 and the other part in the mating conduit section.

Access to the condenser 19 and the electrical connections 81, 82, and 83 contained within the outer part of casing 28, may be had by removing a cover 100 which is normally held in place by screws 101.

Access to the breaker mechanisms is had by removing the cap section 43 which is normally held in place by the three screws 45.

The spark gap unit is removable and replaceable in the manner set forth below. One removes cap 43 and then removes the nut 103 which holds the breaker cam 13 to its driving shaft 48. Then, the cam is pulled off the end of shaft 48. The elbow 98 is disconnected from the rest of the conduit and the lead wires 22 separated at the same time by disengaging the two halves of the pin jack. Then, the three screws 44 which hold the casing sections 41 and 42 together are removed. The section 42 is pulled away from section 41, carrying with it the terminal board 94, lead wires 22, elbow 98, the breaker mechanism and the outer ball bearing. This leaves the spark gap unit exposed with a portion of the shaft 48 and the sleeve 66 protruding through the central opening of the unit. Then, the snap ring 61 is removed, after which the spark gap unit may be removed and replaced with a new unit. The replacement of all the spark gaps as one unit also results in the provision of a new track for brush 20. The new unit is properly located by the engagement of pin 62 in the notch in the peripheral edge of the member 60 of the new spark gap unit. The snap ring 61 is replaced after which section 42 is put in place and secured by the screws 44. As the section 42 is fastened in place the springs 97 on the studs 96 on the terminal board 94 engage all the contacts 92 and thus connect all the spark gaps with the proper lead wires 22. The breaker cam 13 and its retaining nut 103 are then replaced after which the cap 43 is put in place. The elbow 98 is reconnected to its conduit and the pin jack elements reengaged to reconnect the lead wires.

The operation of the system has been described above. It remains to be pointed out that all the apparatus used in the ignition system with the exception of the lead wires, the spark plugs and their transformers, is contained within the casing of a single unit which is bolted to the crankcase of the engine and driven therefrom. The spark plugs and transformers are customarily combined in one unit as is old and well known in the art and as is shown for example in the patent to Whisler No. 1,393,866. There are thus these combined units to be applied, one to each cylinder in the same manner as spark plugs, and the single unit to be applied to the engine crankcase. Then, the last-named unit is electrically connected to the several spark plug and transformer units by lead wires 22, and the system is complete. All the parts which need servicing are contained in the magneto unit with the exception of the spark plug units. There is no apparatus located at intermediate points as is sometimes the case. For example, in a high frequency ignition system for an aircraft engine of the same type for which the present system is adapted, there are

independent spark gap devices one for each cylinder and all located equidistantly from the combined spark plug and transformer units which they serve. There are in such case fourteen separate units to be serviced and either adjusted or replaced. In the present system, a single unit contains all the spark gaps and the one unit can be quickly removed and replaced with a new unit. The construction of this spark gap unit is such as to insure that all the gaps are exactly equal. The spark gap unit can be serviced at the same time that the breaker mechanisms are serviced.

The ignition system is characterized in that distribution is entirely at low tension. The maximum voltage needed to break down the spark gaps is substantially 800. While this voltage exists in the magneto unit up to the spark gap unit, the voltage in the distribution wires is very low after the first or first few oscillations. The system is also characterized by the use of a frequency high enough to give the advantage of small loss by leakage in fouled spark plugs and low enough to enable low distribution losses and the use of low tension distribution with all the apparatus, except the combined spark plug and transformer, located compactly and for convenient servicing in the magneto housing.

What we claim is:

1. In an ignition system, a condenser, a magneto including a rotor and breaker mechanism and a secondary coil connected to periodically charge said condenser, a plurality of discharge circuits for said condenser, a distributor driven synchronously and in phase relation with said rotor and breaker mechanism to successively connect said circuits to the condenser to receive a discharge therefrom, a plurality of spark plugs, a plurality of spark plug transformers, a plurality of spark gaps each discharge circuit including a spark gap and the primary of a transformer, a secondary circuit for each transformer including a spark plug; said condenser, distributor and all said spark gaps being grouped with said magneto as one unit and the spark plugs and transformers being located remotely from said unit.

2. In an ignition system, a condenser, a magneto including a rotor and breaker mechanism and a secondary coil connected to periodically charge said condenser, a plurality of discharge circuits for said condenser, a distributor driven synchronously and in phase relation with said rotor and breaker mechanism to successively connect said circuits to the condenser to receive a discharge therefrom, a plurality of spark plugs, a plurality of spark plug transformers, a plurality of spark gaps each discharge circuit including a spark gap and the primary of a transformer, a secondary circuit for each transformer including a spark plug; said condenser, distributor, and all said spark gaps being grouped with said magneto as one unit and the spark plugs and transformers being located remotely from said unit, and a member having a chamber in which all said spark gaps are hermetically sealed, said member being conveniently removable from the group of elements at the magneto and replaceable by a new unit.

3. Ignition means, comprising, a magneto having a stator and a rotor forming a magnetic circuit, means for driving said rotor to make and break said circuit periodically, primary and secondary coils through which circuit extends, breaker mechanism, a primary circuit including the primary coil and breaker mechanism, actuating means for said breaker mechanism for

opening and closing said primary circuit synchronously and in phase relation with the breaking and making of the magnetic circuit; a condenser connected to said secondary coil to be charged thereby on each opening of the primary circuit, a series of pairs of electrodes affording spark gaps between them, a single casing in which said electrodes are mounted and having a hermetically sealed chamber in which all said spark gaps are located, a distributor driven synchronously and in phase relation with the rotor and breaker mechanism for successively connecting said condenser to one set of electrodes, terminals connected to the electrodes of the other set to receive the lead wires of spark plug transformers; and common means for supporting the magneto, condenser distributor and the casing containing the spark gaps.

4. In ignition means, a casing, a distributor shaft mounted in said casing, a distributor brush carried by the shaft, a chambered member mounted in said casing for convenient removal and replacement and presenting opposed flat faces one of which lies adjacent the path of travel of said brush, and a circular series of pairs of electrodes fixed in the walls of said member, the electrodes of each pair mounted in axial alignment with their inner and confronting ends spaced apart to form a spark gap, the outer ends of the electrodes having contacts located one series on each of said faces, the series of contacts on said last-named face adapted to be successively engaged by said distributor brush.

5. In ignition means, a casing, a member mounted therein for convenient removal and replacement and located between the ends of the casing and extending across the same, said member having a chamber therein two walls of which have their outer faces paralleling the ends of the casing, a circular series of contacts on each said face, a circular series of electrodes mounted in each said wall and connected one to each contact of the adjacent series, the electrodes of the two series extending into said chamber from opposite directions and terminating with confronting ends which are spaced to form spark gaps, a distributor brush mounted in said casing between one end thereof and one said face and adapted to successively engage the series of contacts therein, a driving shaft carrying said brush, and a terminal board mounted in said casing between the other end thereof and the other face of said member, said board having a circular series of terminals one for each said contact and means on each terminal to engage the adjacent contact on said last-named face.

6. Ignition means comprising a casing having two reversely disposed cup-shaped parts forming between them a chamber closed at both ends and separable along a parting plane intermediate its ends, a distributor shaft having a bearing in the end of one part and extending into said chamber, a distributor brush carried by said shaft, a terminal board fixed to the end of the other part and having a series of terminals, a member mounted in the first-named part near said parting plane for convenient removal and replacement and having a closed chamber with two walls thereof substantially paralleling said ends and board, two series of contacts each equal in number to said terminals and mounted one series in the outer face of each said wall, the contacts of one series in one face adapted to be successively engaged by said brush, means on said terminals for simultaneously and severally

connecting them to the contacts in the other series, two series of electrodes each series equal in number to the contacts in one series and fixed one series in each said wall, each electrode of one series extending into said chamber in axial alignment with an electrode of the other series and the inner and confronting ends of each pair of aligned electrodes being spaced apart to form spark gaps, all the spark gaps being removable and replaceable in one operation by removal of said member and replacement of it with a new and similar member after the casing parts have been separated at the parting plane.

7. Ignition means comprising a casing having two reversely disposed cup-shaped parts forming between them a chamber closed at both ends and separable along a parting plane intermediate its ends, a distributor shaft having a bearing in the end of one part and extending into said chamber, a distributor brush carried by said shaft, a terminal board fixed to the end of the other part and having a series of terminals, a conduit for lead wires connected to the last-named part and entering said chamber adjacent said terminal board, a member mounted in said first-named part near the parting plane for convenient removal and replacement and having a closed chamber with two walls thereof substantially paralleling said ends and board, two series of contacts each equal in number to said terminals and mounted one series in the outer face of each said wall, the contacts of one series in one face adapted to be successively engaged by said brush, means on said terminals for simultaneously and severally connecting them to the contacts in the other series, two series of electrodes each equal in number to the contacts in one series and fixed one series in each said wall, each electrode of one series extending into said chamber in axial alignment with an electrode of the other series and the inner and confronting ends of each pair of aligned electrodes being spaced apart to form spark gaps, all the spark gaps being removable and replaceable in one operation by removal of said member and replacement of it with a new and similar member after the casing parts have been separated at the parting plane.

8. In ignition means, a casing divided off into three chambers including an inner chamber for the distributor, an outer chamber for the breaker mechanism and an intermediate chamber for a series of spark gaps and a terminal board, a shaft mounted in the inner wall of the inner chamber and in the dividing means between the outer and middle chamber, a distributor brush on said shaft and located in the inner chamber, breaker mechanism in the outer chamber including an actuating cam fixed on said shaft, the dividing means between the middle and inner chambers comprising a member having two walls with outer faces paralleling the ends of the casing and affording between them a chamber, two series of contacts arranged one series in each said outer face, the contacts of one series being successively engageable by the distributor brush, two series of electrodes mounted one series in each said wall, the contacts of each series being connected one to each of the electrodes of the adjacent series, each electrode of one series extending into said chamber in axial alignment with an electrode of the other series, the inner and confronting ends of each pair of aligned electrodes being spaced apart to form a spark gap, a terminal board in the middle chamber fixed to the outer wall thereof and having terminals,

the number of contacts in each series and the number of electrodes in each series being equal to the number of terminals, each terminal having means to yieldingly engage a contact of the other series, said casing being made in separable sections with parting planes one extending through the outer chamber and one through the

middle chamber, the member containing all the spark gaps being removable and replaceable and when removed allowing access to the inner chamber.

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